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DEVELOPING A LOW COST MICROCONTROLLER BASED DATA ACQUISITION SYSTEM TO MONITOR CIVIL STRUCTURES

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ABSTRACT

Ultrasonic measurements are used in structural engineering to determine material properties, detect defects and assess deterioration. Ultrasonic wave propagation characteristics that can be used for these purposes are: velocity, attenuation, frequency, and energy. Rapid growth in demand for value-added techniques for health monitoring of structures has focused worldwide interest on sensors as the provider of an effective solution to measurement problems. Recent advances in measurement technology have demonstrated that ultrasonic sensors are suitable for the monitoring of civil structures. Nowadays engineers of civil department are inventing new sophisticated measuring instruments regularly. Unfortunately due to high cost, these instruments are procured only by large companies. Most of the small and medium size companies can't afford this due to economic problem. So our main target should be to develop or invent some good measuring instruments at low cost for the sake of these companies. In this project we have tried something to do this. The aim of our project is to design a microcontroller based circuit to detect any defects in a concrete structure that is easy to handle & pocket friendly.

Keywords: ***Ultrasonic Transducer, Pulse Velocity Test, 8051 Microcontroller, LCD Display***

I. INTRODUCTION

It is now well established that by propagating ultrasound in a given medium, useful information about the medium can be generated by analyzing the transmitted signals. This is analogous to all other methods of characterization and analysis also founded upon wave-material interaction phenomena. These are: Optics, X-ray, IR, Raman Spectroscopy, NMR, neutron, g-ray, mass spectrometry, etc. Ultrasound differs from these methods because it does not require sample preparation, is non-hazardous, provides the means to determine mechanical properties, microstructure, imaging, & microscopy, is portable, and is cost-effective. Furthermore, ultrasound is applicable to all states of matter, with the exceptions of plasma and vacuum. Propagation of ultrasound in a medium is not affected by its optical opacity.

1.1 Introduction To Pulse Propagation Through Concrete

Three types of waves are generated by an impulse applied to a solid mass. Surface waves having an elliptical particle displacement are the slowest, whereas shear or transverse waves with particle displacement at right angles to the direction of travel are faster. Longitudinal waves with particle displacement in the direction of travel (sometimes known as compression waves) are the most important since these are the fastest and generally provide more useful information. Electro acoustical transducers produce waves primarily of this type; other types generally cause little interference because of their lower speed. The wave velocity depends upon the elastic properties and mass of the medium, and hence if the mass and velocity of wave propagation are known it is possible to assess the elastic properties. For an infinite, homogeneous, isotropic elastic medium, the compression wave velocity is given by:

$$V = \sqrt{\frac{K \cdot E_d}{\rho}}$$

where V = compression wave velocity (km/s)

$$K = \frac{(1 - v)}{(1 + v)(1 - 2v)}$$

E_d = Dynamic Modulus of Elasticity (kN/mm^2) ; ρ = Density (kg/m^3) and v = Dynamic Poisson's Ratio

In this expression the value of K is relatively insensitive to variations of the dynamic Poisson's ratio v, and hence, provided that a reasonable estimate of this value and the density can be made, it is possible to compute E_d using a measured value of wave velocity V. Since v and p will vary little for mixes with natural aggregates, the relationship between velocity and dynamic elastic modulus may be expected to be reasonably consistent despite the fact that concrete is not necessarily the 'ideal' medium to which the mathematical relationship is applied.

1.2 Pulse Velocity Method

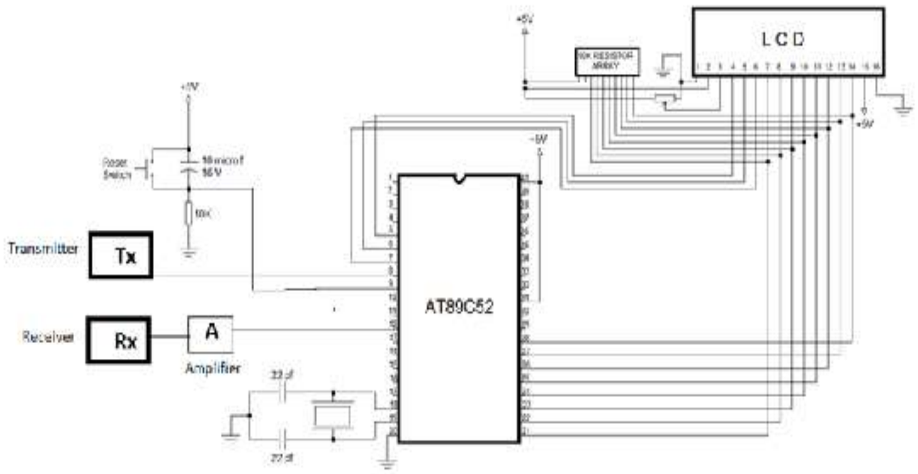
This can be sub divided into two parts

1) Mechanical sonic pulse velocity method, which involves measurement of the time of travel of longitudinal or compressional waves by a single impact hammer blow or repeated blows.
2) Ultrasonic pulse velocity method, which involves measurement of the time of travel of electronically generated mechanical pulses through the concrete.

Out of this two, Ultrasonic pulse velocity method is the most popular method all over the world. When mechanical impulses are applied to a solid mass, three different kinds of waves are generated. These waves are known as longitudinal waves, shear waves and surface waves. These three waves travel at different speed. The longitudinal wave travels as twice fast as other two types. The shear wave is not so fast, the surface wave is the slowest among all waves. The pulses can be generated either by hammer blows or by the use of electroacoustic transducer. Electroacoustic transducers are preferred as they provide better control on the type and frequency of pulses generated. Ultrasonic pulse velocity method consists of measuring the time of travel of ultrasonic pulse, passing through the concrete to be tested. The pulse generator circuit consists of ultrasonic circuit for generating ultrasonic pulses and a transducer for transforming these electronic pulses into mechanical energy having vibration frequencies in the range of 15 to 50 KHz. The time of travel between initial onset and the reception of the pulse is measured electronically. The entire length between the transducer divided by the time of travel gives the average velocity of the propagation.

II. BASIC OF THE MICROCONTROLLER BASED MEASUREMENT SYSTEM

Fault detection is a crucial step in implementing energy efficient changes to building and industrial systems. Fault detection is utilized to determine that a problem has occurred within in a certain channel or area of operation. Now all this techniques are effective but very much difficult to handle and costly. Our aim is to design a fault detection system so that the software application identifies the reason for the sub-optimal performance, or fault, so that the business or organization can pinpoint the fault, and fix it. But already there is many more fault detecting process is available in the markets that are effective to a great extent. So we aim to develop a system that is easy to implement and also cost effective. The aim of our project is to design a microcontroller based circuit to detect any defects in a concrete structure that is easy to handle & pocket friendly. To achieve our aim we have designed a transmitter circuit with the help of IC 4013, IC4017 & some discrete components. The receiver circuit is designed with the help of IC4017 and some discrete components like resister capacitor etc, and last of all the microcontroller circuit is designed with the help of AT89C52 and several capacitors and resistors. To display the results of the microcontroller output one LCD is connected with it. The signal that can successfully penetrate the concrete block to see whether there is any fault in the concrete block is of the order of 54 kHz. But here to accomplish our project we are using a signal of 40 kHz to test our hardware setup. The signal of the range of 40 kHz generally detects the concrete as an obstacle and deals with a problem of penetrating the concrete block. The reason behind the use of less compatible signal is because of the limitation of the cost and availability of the transducer generating the signal in the range of 54 kHz.

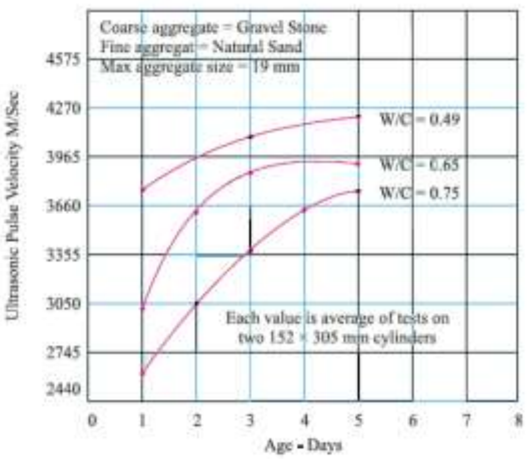


In our project we are using the microcontroller AT89C52, The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control application. For the calculation of the delay of the signal when it passes through the concrete block, we have used the microcontroller. We used the micro controller more of as a practical clock which counts the time delay in mille seconds with the help of its counter mode. In the veroboard we have connected a chip holder to hold the microcontroller so that it is easy for us to change the microcontroller chip if it is damaged or not functioning properly. As it can be seen in the circuit diagram we have used the port 1 pins to receive the signals from transmitter and receiver. The transmitter when transmits the 40 KHz signal the corresponding pin say pin 1 of port 1 gets a signal, and when the receiver receives the signal the corresponding port of microcontroller sat pin 2 of port 1 is at high. When microcontroller detects that the pin 1 of port 1 is at high (i.e. 1) then it loads a value in the TMOD special function resister so that the timer is on and the microcontroller acts as a 16 bit auto reload counter. There is a delay subroutine in the memory which provides a delay of 1 mille seconds. Microcontroller after executing the delay subroutine checks if the corresponding bit of the receiver is high or not. If the pin is high then it stops the counting and shows the result in the LCD display. But if the pin is not high then it resumes its counting with one mille seconds delay each. The LCD circuit is connected to the microcontroller circuit as the display unit. When the microcontroller is done counting it displays the result in the LCD display screen. The pins 4 ,5, 6 are connected to the microcontroller port 1, and pins 7 to 14 are connected to the port 2 of the microcontroller, as well as to the 10K register array.

III. TABLE AND GRAPH

Suggested Pulse Velocity in Concrete

Pulse Velocity (m/s)	General Conditions
4575	Excellent
3660- 4575	Good
3050 - 3660	Questionable
2135 - 3050	Poor
2135	Very Poor



IV. CONCLUSION

Ultrasonic pulse velocity measurement has been found to be a valuable and reliable method of examining the interior of a body of concrete in a truly nondestructive manner. Modern equipment is robust, reasonably cheap and easy to operate, and reliable even under site conditions; however, it cannot be overemphasized that operators must be well trained and aware of the factors affecting the readings. It is similarly essential that results are properly evaluated and interpreted by experienced engineers who are familiar with the technique. For comparative purposes the method has few limitations, other than when two opposite faces of a member are not available. The method provides the only readily available method of determining the extent of cracking within concrete; however, the use for detection of flaws within the concrete is not reliable when the concrete is wet. The aim of this project is to design a microcontroller based circuit to detect any defects in a concrete structure that is easy to handle & pocket friendly. So the main part of this project is to design Microcontroller Based circuit. It is mainly our R&D project and we have tried to use the transmitter circuit which generates 40 kHz ultrasonic frequency. So it was our hope that it will penetrate the plasma state of concrete structure. But later we have studied that only 54 KHz transducer can penetrate concrete. The price of this transducer is more than one lakh which exceed total project cost. So we could not forward our R and D work after a certain level. In this project we made the transmitter circuit and checked by the CRO which generates the 40 kHz frequency. Here in this project we use many of components for transmitter like capacitor, inductor, resistor, crystal oscillator, IC4017, IC4013 etc. Then we have burned the program in the microcontroller chip. We have not tested the setup practically because it is partially completed. But if 54 KHz will be transducer in place of 40 KHz, then the system may work fine.

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